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OBJECTIVES

1. Conduct sensitivity analyses, including instrument-related and environment-related error and accuracy analyses, of the various vegetation index equations.

2. Finish version 1 of the MODIS Vegetation Index ATBD.

3. Functionally couple vegetation index products to plant biophysical parameters.

TASK PROGRESS

1. Vegetation Index Manuscripts

A second MODIS vegetation index sensitivity study was completed and submitted to TGARS, IEEE for publication. The paper is entitled "An error and sensitivity analyses of the atmospheric- and soil-correcting variants of the NDVI for MODIS-EOS', by A.R. Huete and H. Liu. The abstract for this paper follows:

ABSTRACT - Several soil- and atmospheric correcting variants of the normalized difference vegetation index (NDVI) have been proposed to improve its' accuracy in estimating biophysical plant parameters. In this study, a sensitivity analyses, utilizing simulated and observational data, was conducted on the NDVI and improved variants by analyzing the atmospheric-and soil- perturbed responses of each VI as a continuous function of two vegetation parameters (LAI and %green cover). Absolute and percent relative errors, and vegetation equivalent noises (VEN) were calculated for soil and atmospheric influences, separately and combined. The NDVI variants included the soil-adjusted vegetation index (SAVI), the atmospherically resistant vegetation index (ARVI), the soil and

atmospherically resistant vegetation index (SARVI), the modified SAVI (MSAVI), and modified SARVI (MSARVI).

Soil and atmospheric error were of similar magnitudes, but varied with the vegetation index. All new variants outperformed the NDVI. It was found that the atmospherically resistant versions minimized atmospheric noise, but enhanced soil noise while the soil adjusted variants minimized soil noise, but remained sensitive to the atmosphere. The SARVI, which had both a soil and atmosphere calibration term, performed the best with an absolute error of +/-0.06, relative error of 10%, and VEN of +/-0.33 LAI. By contrast, the NDVI had absolute and relative errors of 0.12, 20%, and 0.82 LAI respectively.

A second, follow-up manuscript is in preparation using a systems based' noise and uncertainty analysis of the NDVI. By utilizing a soil and atmospheric feedback loop and atmospheric feed-forward loop, the modified NDVI was reduced to a total relative error of 4%.

2. Vegetation Index ATBD

The first iteration of the vegetation index ATBD was completed in September. The final document was 46 pages in length with a 5 page Appendix which consisted of the formulation and equations for the error analysis of three instrument-related cases:

i. The error associated with a 5% absolute sensor calibration accuracy in bands 1, 2, and 3.

ii. The error associated with a 20% band to band co-registration requirement in the cross- and along-track directions, and that associated with the 10% goal.

iii. The error associated with a spectral band output change due to a shift in center wavelength. This varies from 0.5% (bands 1,2) to 2% (bands 3, 4) as shown in the MODIS CAL ATBD, Version 0 (Barker et al., 1993; p.12).

The 3 sources of error and noise presented were not coupled with each other nor with environmental sources of noise such as that due to atmospheric and soil background variance. This end-to-end sensor model needs further development.

The level 3, compositing algorithm for the vegetation index will need further work as explained in "Next Quarter Activities". It was suggested in

the ATBD that the NDVI and improved, MODIS VI be given separate parameter numbers under the same product number. The level 3 version of the VIs will also need separate parameter identifications.

3. Niger-HAPEX Activities:

The sensitivity of the VIs to green leaf area index (LAI), total biomass, and intercepted photosynthetically active radiation (IPAR) is being studied using data collected at HAPEX-Sahel. Temporal integration of the VIs appears well correlated with total biomass and integrated IPAR. The slope of the integrated VI with biophysical data was different for each land cover type and appeared to be a measure of the growth efficiency for each site. At the moment, CO2 data is being utilized to determine the relationship between VIs and net ecosystem production.

Plant component reflectance and transmittance spectra, obtained with an integrating sphere attached to an SE 590, are being used to simulated the various land cover types of HAPEX-Sahel with the SAIL model. Leaf and soil spectra are input to the model. Leaf orientation, sun angle, and LAI are the estimated variables to simulate the canopy. This simulated data will be used in sensitivity studies as well as to compare with observational field canopy and satellite measurements.

NEXT QUARTER ACTIVITIES

Various studies are being initiated that concern the level 3, compositing of the vegetation index. The major factors in level 3 work are the influences and uncertainties introduced by varying sensor view angles as well as the associated effects due to ground and atmospheric anisotropies. An assessment of all the uncertainties involved in the maximum value compositing (MVC) technique will be initiated and compared with new compositing approaches presented in the literature. The MVC technique assumes a lambertian surface which, in most cases, is not valid.

The level 3 compositing studies to be initiated will involve work with Myneni's canopy model, SAIL, Lowtran, 6S, and various BRDF models, including those of Hapke, Verstraete and Roujean. A spectral mixtures program will also be implemented to analyze multitemporal VI patterns.

PUBLICATIONS

Huete, A.R., and Liu, H., "An error and sensitivity analyses of the atmospheric- and soil-correcting variants of the NDVI for MODIS-EOS", IEEE Trans. Geosc. Remote Sensing (Submitted 9-93).

van Leeuwen, W.J.D., Huete, A.R., Duncan, J., and Franklin, J., 1993, Radiative transfer in shrub savannah sites in Niger -- preliminary results from HAPEX-II-Sahel: 3. Optical dynamics and vegetation index sensitivity to biomass and plant cover, Agric. and Forest Meteorology (Accepted, 8/93).

Qi, J., Chehbouni, A., Huete, A.R., and Kerr, Y.H., 1993, A modified soil adjusted vegetation index, Remote Sens. Environ. (Accepted 8/93).

Franklin, J., Duncan, J., Li, X., Huete, A.R. and van Leeuwen, W.J.D., 1993, Radiative transfer in a shrub savannah -- preliminary results from HAPEX- II-Sahel: 2. Modelling surface reflectance and vegetation indices using a geometrical-optical approach, Agric. and Forest Meteorology (Accepted, 8/93).